Plans to Search New Particles Decaying to Dijets at CMS

Sertac Ozturk
Cukurova University / Fermilab

for CMS Collaboration

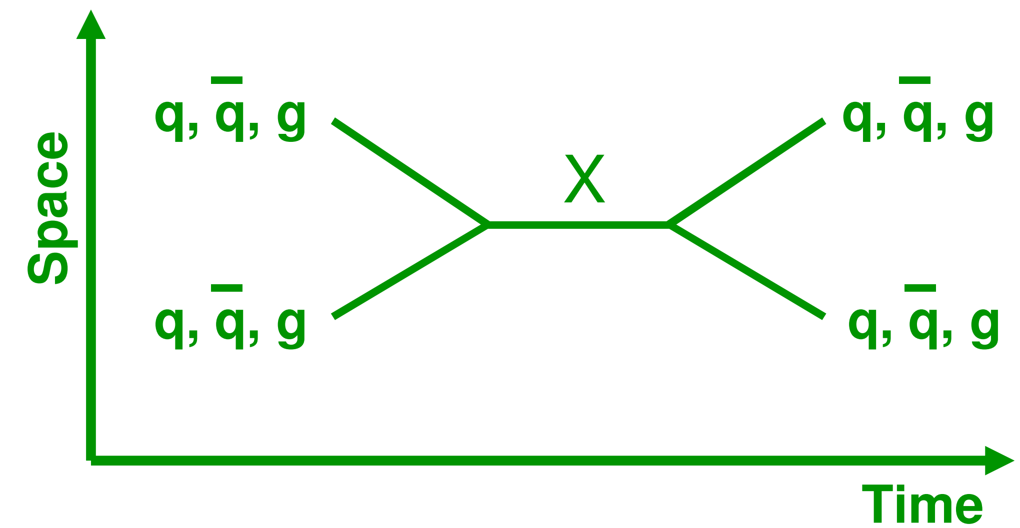
APS April Meeting 2010
February 13, Washington, DC

Outline

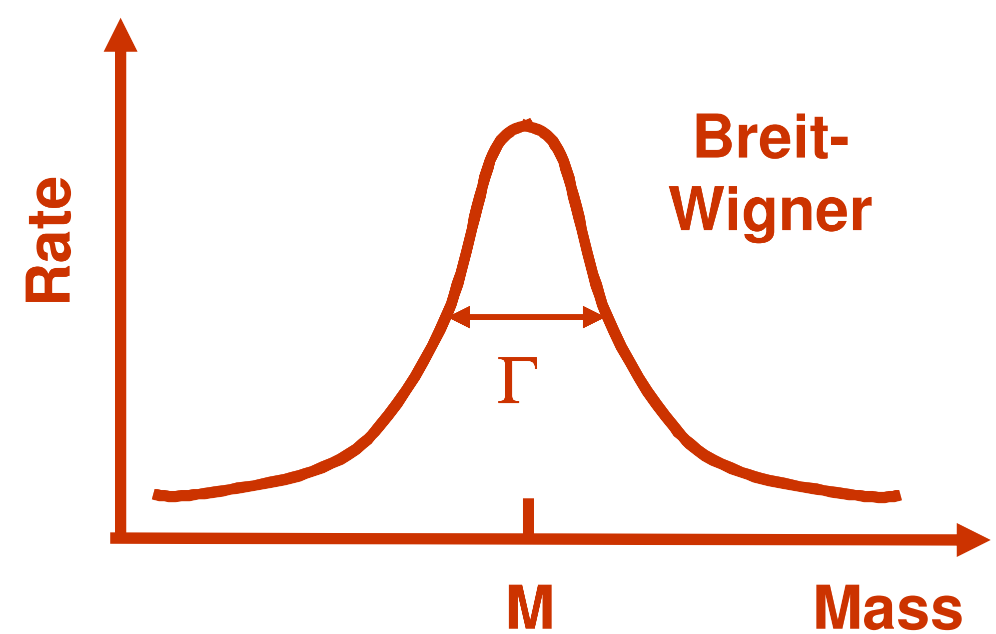
- Motivation
- Analysis Strategy
- Limits with Statistical Error Only
- Limits with Including Systematics
- Results
- Conclusion

Motivation

- We search for new physics beyond SM with Dijets
- New particles that decay to dijets
  - ✓ Produces in "s-channel"
  - ✓ Parton-Parton Resonaces
    - Observed as dijet resonances.
- Many Models have small with Γ



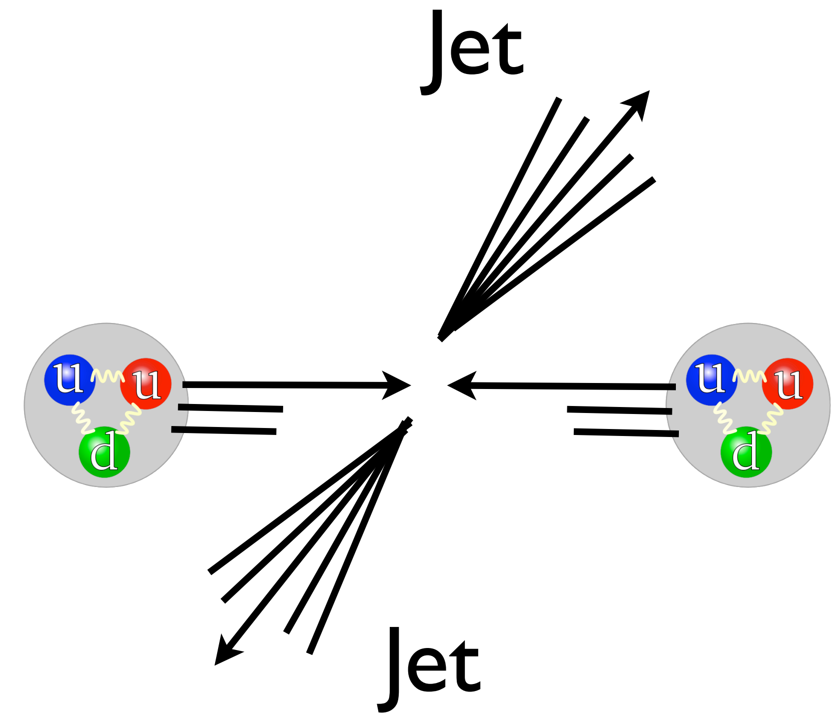
Model Name	X	Color	J^P	Γ / (2M)	Chan
E_6 Diquark	D	Triplet	0^+	0.004	ud
Excited Quark	q*	Triplet	$½^+$	0.02	qg
Axigluon	A	Octet	1^+	0.05	$q\bar{q}$
Coloron	C	Octet	1^-	0.05	$q\bar{q}$
Octet Technirho	ρ_{T8}	Octet	1^-	0.01	$q\bar{q}$,gg
R S Graviton	G	Singlet	2^-	0.01	$q\bar{q}$,gg
Heavy W	W '	Singlet	1^-	0.01	$q_1\bar{q}_2$
Heavy Z	Z '	Singlet	1^-	0.01	$q\bar{q}$

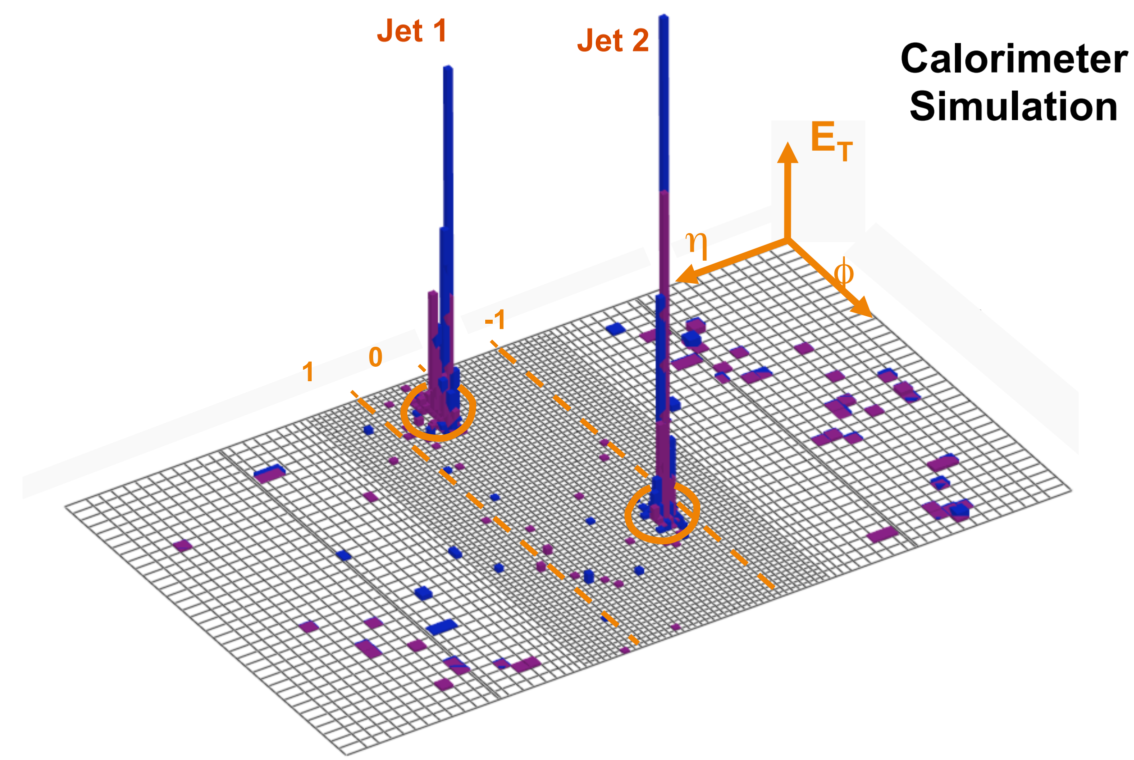


Dijet in Standard Model

- What is a Dijet?
  - ✓ Dijet results from simple 2→2 scattering of "partons"
  - ✓ Dijets are events which primarily consist of two jets in the final state.
- We search for the new particles in "Dijet Mass" spectrum
  - ✓ If a resonance exist, It can show up as a bump in Dijet Mass spectrum
- Dijet Mass from final state

$$m = \sqrt{(E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2}$$



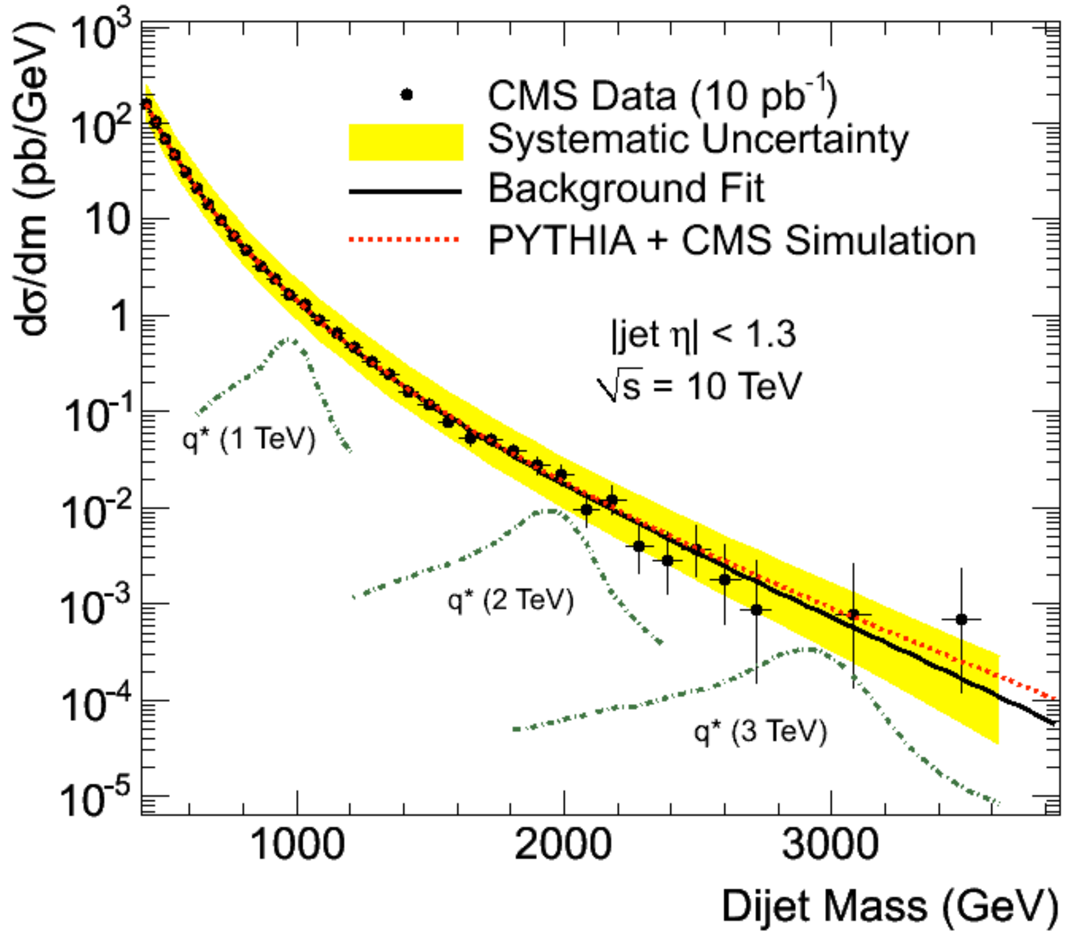


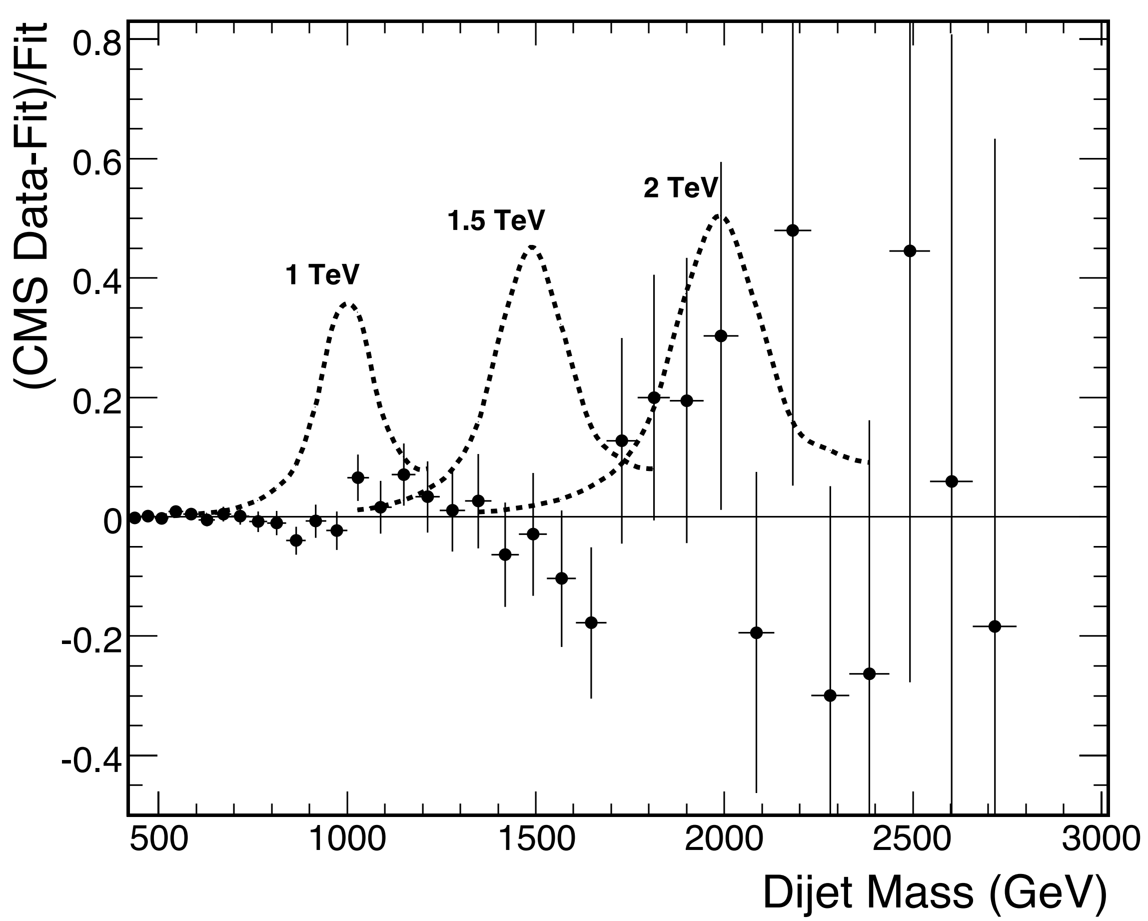
Analyses Strategy

- Signal
  - ✓ $G \to gg$, $q^* \to qg$ and $G \to qq$ resonances at 0.7 TeV, 2TeV and 5 TeV.
- Background
  - ✓ QCD Dijet
- Event Selection
  - ✓ $|\text{Jet } \eta| < 1.3$
  - ✓ Jets from Anti-Kt algorithm with R=0.7
  - ✓ MET/SumET<0.3 to reject unphysical events.
  - ✓ Dijet Mass plots use variable dijet mass bins
    - The bins are equal to dijet mass resolution
  - ✓ Unprescaled jet trigger (HLT_Jet110)
- Caution: All plots are made using SisCone with R=0.7. Our plan is to use Anti-kt instead of SisCone.

Data compared to Signal

- We produce pseudo-data from PYTHIA QCD dijets.
  - ✓ Stat. fluctuation for 10 pb^{-1}
- The pseudo-data is compared to PYTHIA and NLO QCD
  - ✓ Like we will do with real data
  - ✓ These is no evidence for dijet resonances
- We would proceed to set limits





Setting Limits

- To calculate limit on new particle cross section we use a binned likelihood.

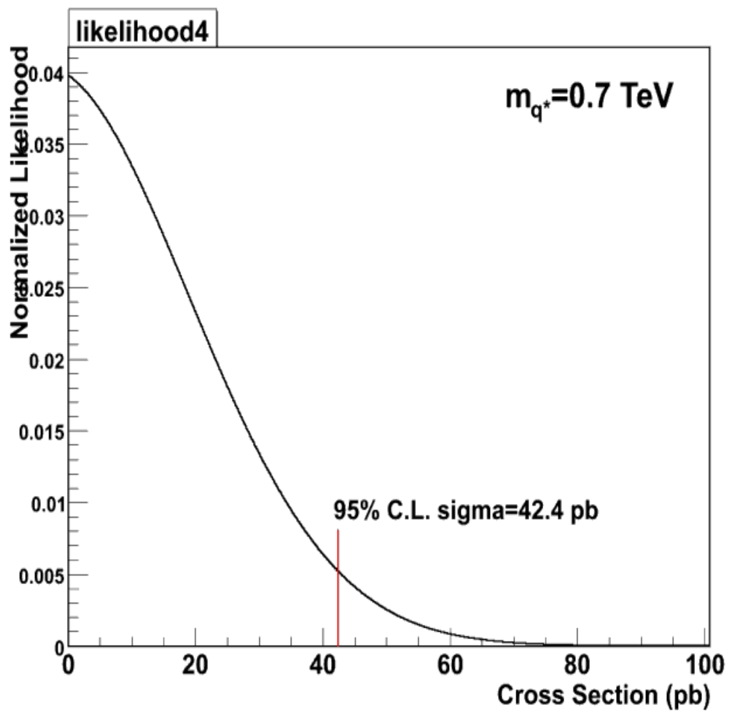
$$L = \prod_i \frac{\mu_i^{n_i} e^{-\mu_i}}{n_i!} \qquad \mu_i = \alpha N_i(S) + N_i(B).$$

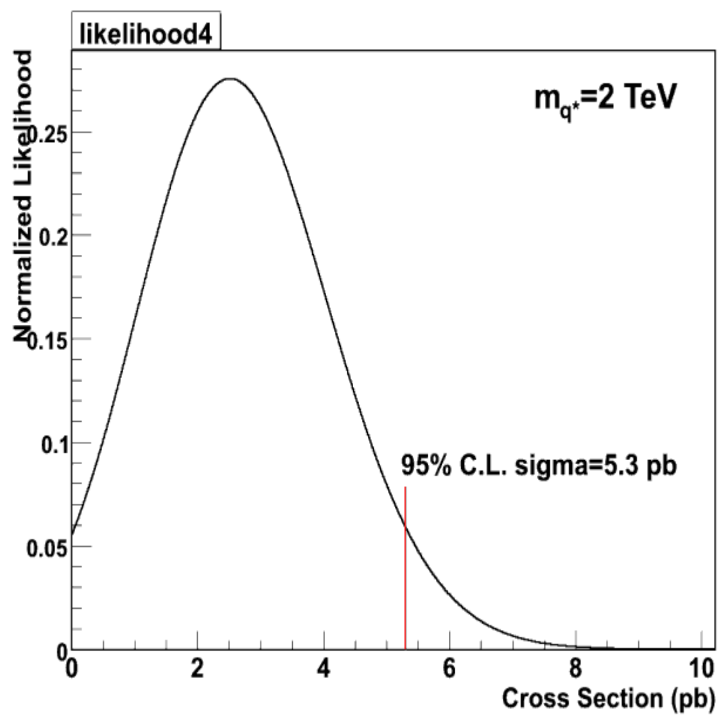
- n_i: Measured # of events in data
- $N_i(S)$: # of event from signal
- $N_i(B)$: Expected # of event from background

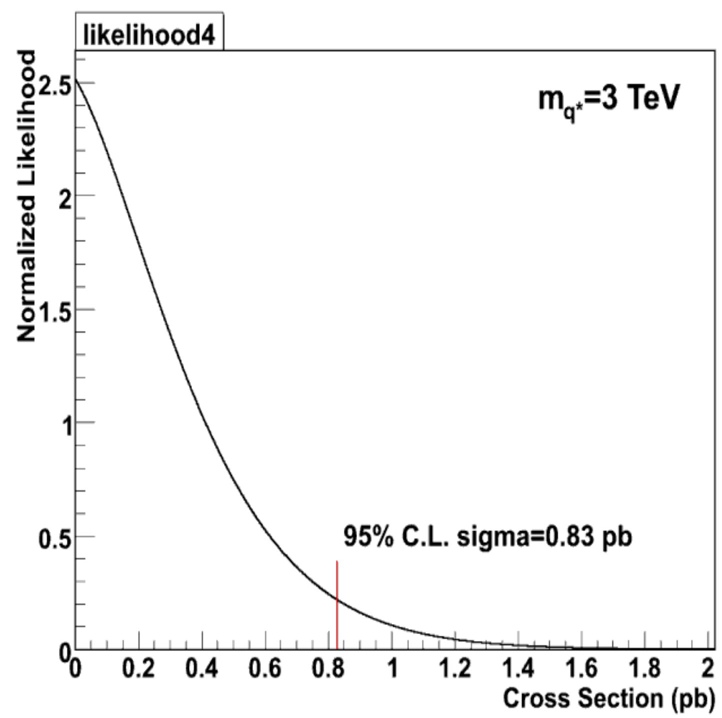
- The signal comes from our dijet resonance shapes for qq, qg and gg.
- The background comes from fit.
- We calculate likelihood as a function of signal cross section for resonances with mass from 0.7 TeV to 3.5 TeV in 0.1 TeV steps.

Likelihood with Statistical Error

- Likelihood distributions as function of signal cross section for different resonance mass are shown.
- 95% C.L. upper limit on cross section calculated.



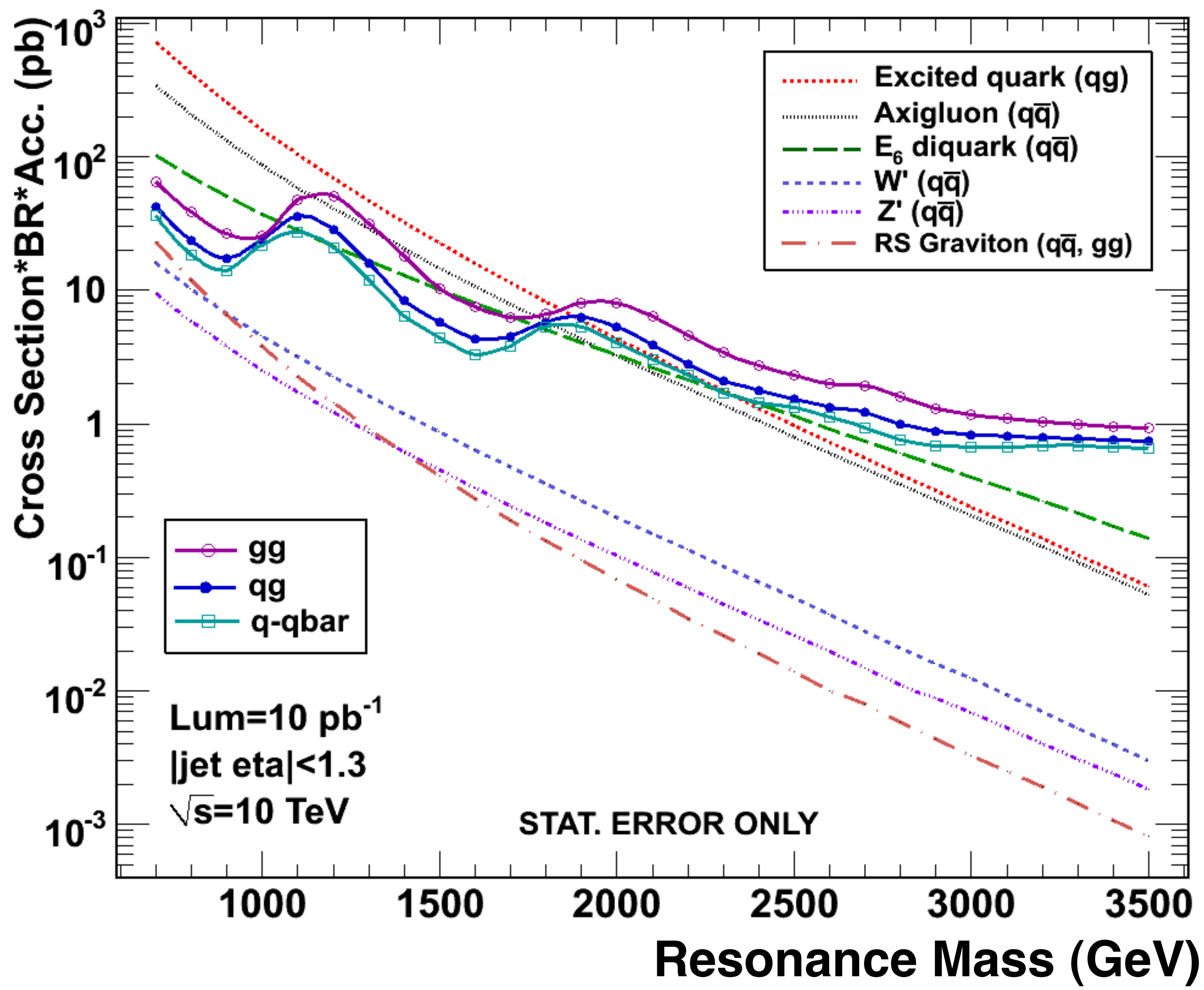




$$\frac{\int_0^{\sigma_{95}} L(\sigma)d\sigma}{\int_0^{\infty} L(\sigma)d\sigma} = 0.95$$

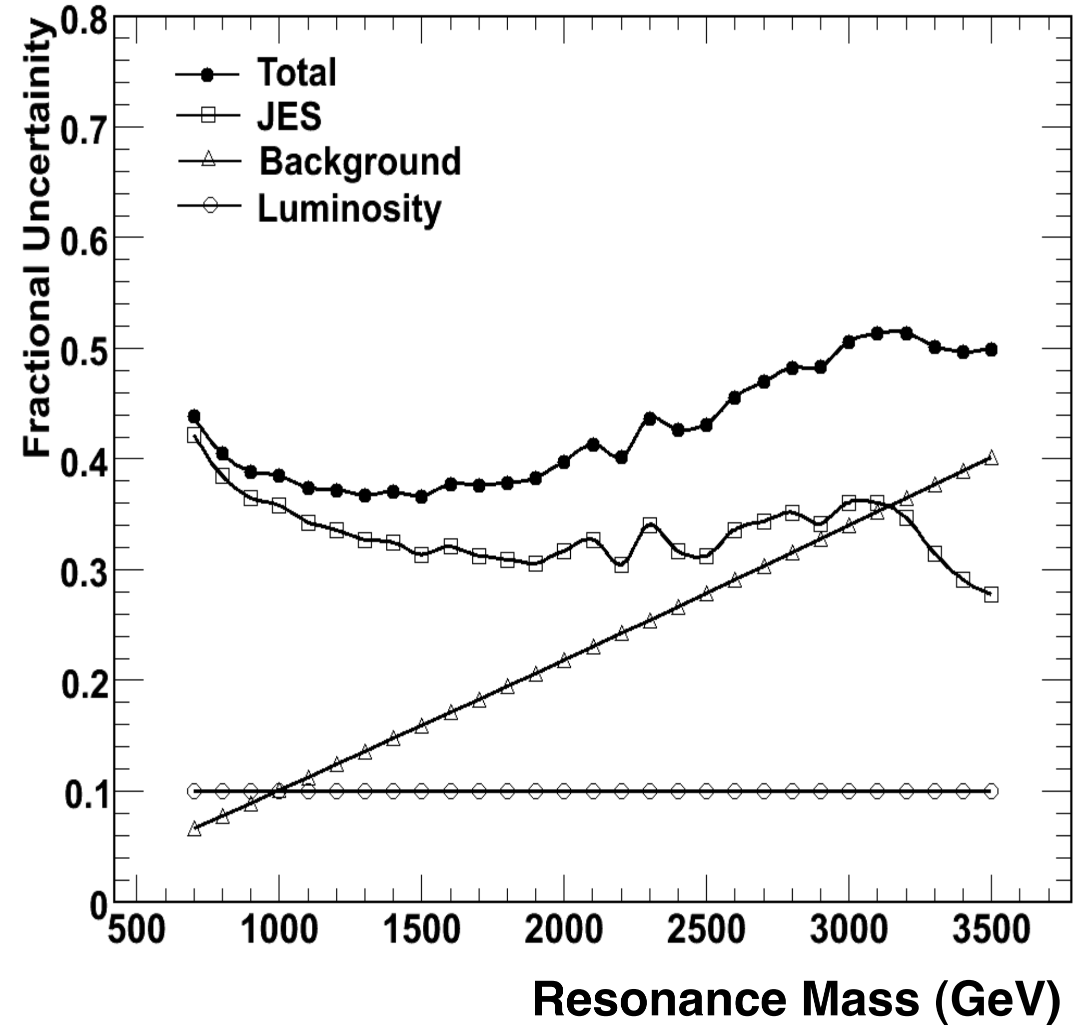
Dijet Resonance Limits with Statistical Uncertainties Only

- 95% C.L. upper limit compared to cross section for various models.
  - ✓ Shown seperatly for qq, qg ang gg resonances.
  - ✓ The sensitivity for qq parton pair resonances is higher than the others parton pair resonances



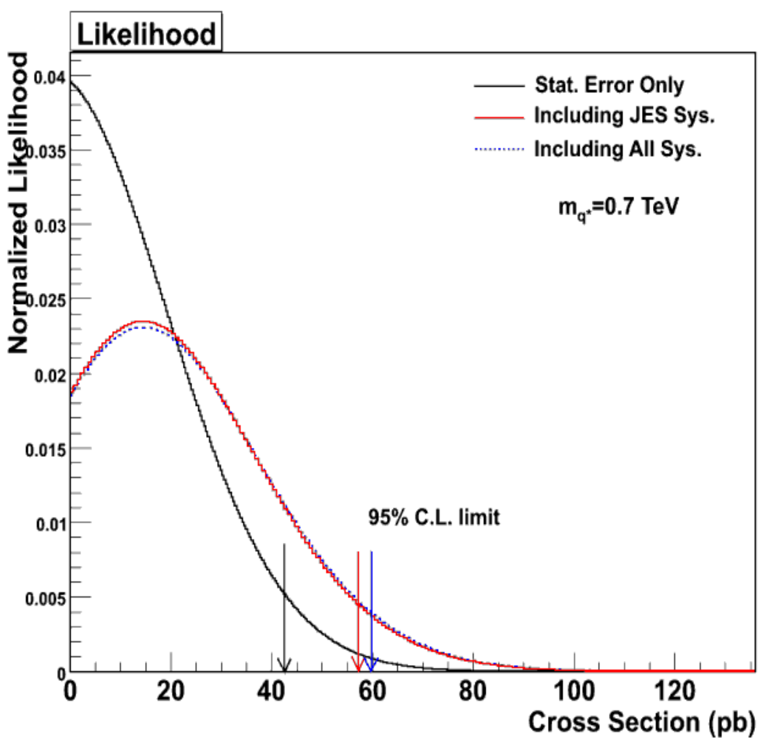
Systematic Uncertainties

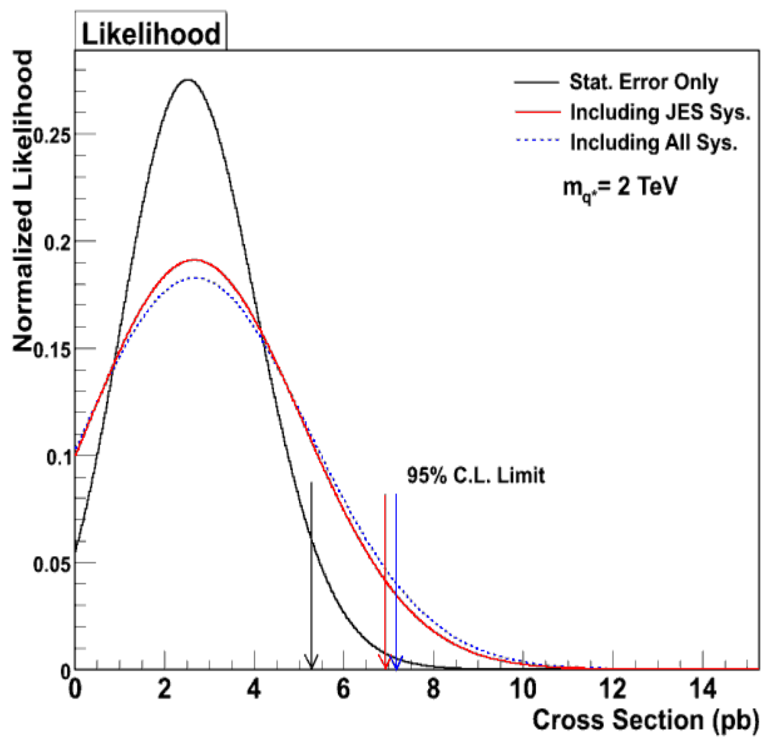
- We found the uncertainty in the dijet resonance cross section from following sources
  - ✓ Jet Energy Scale (JES)
    - Uncertainty assumed to be 10% at start-up
  - ✓ Choice of background parametrization
    - We consider 3 functional form used by CDF
  - ✓ Luminosity
    - Uncertainty assumed to be 10% at start-up
- We add in quadrature the individual systematic uncertainties
  - ✓ Total systematic uncertainty varies from 45% at m=0.7 TeV to 50% at m=3.5 TeV

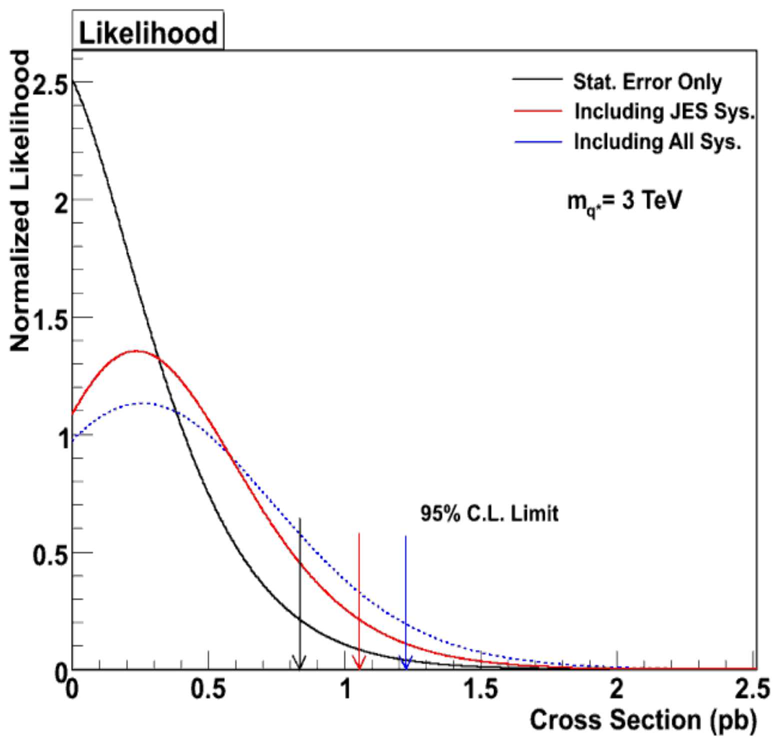


Likelihoods with Systematics (for qg)

- We convolute Poisson likehoods with Gaussian systematics uncertainties.
  - ✓ Total likelihood including systematics is broader and gives higher upper limits.

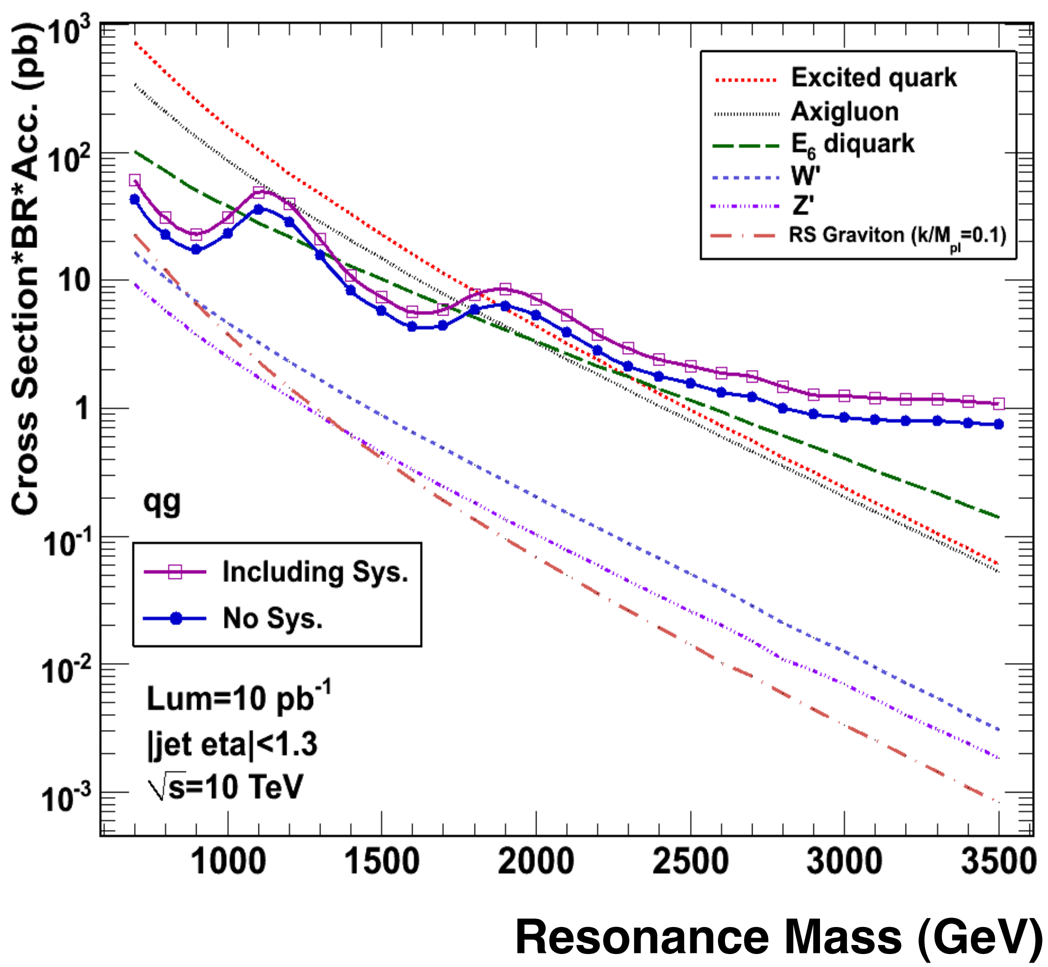


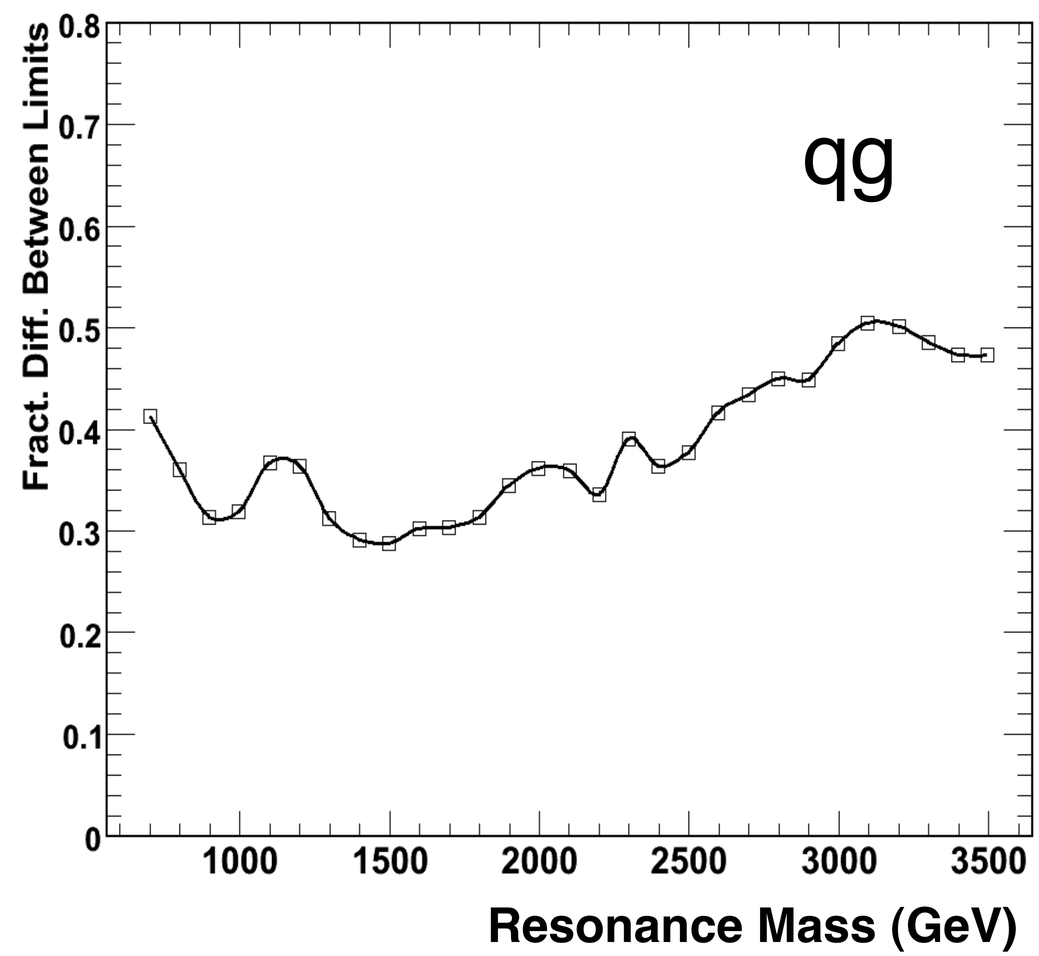




Effect of Systematics on Limit

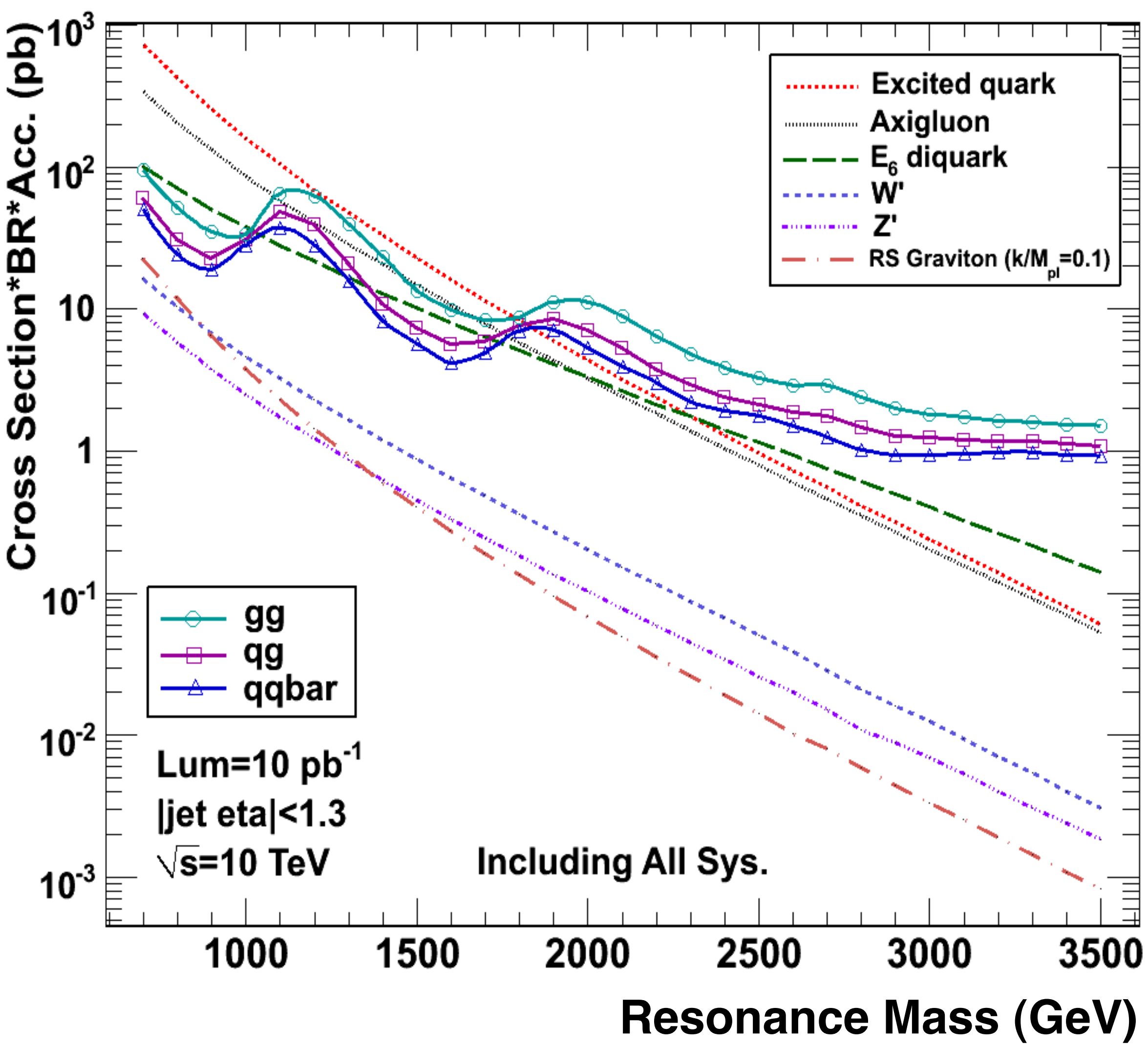
- Cross section limits increase by about 30%-50% with systematic uncertainties
  - ✓ q* mass limits decrease by about 100 GeV with systematic uncertainties.
  - ✓ Similar changes for qq and gg resonances.





Results

- Final limits for qq, qg, gg resonaces compared to models.
  - ✓ To set limit for excited quark, qg resonance is used.
  - ✓ For axigluon, coloron and E_6 diquark, qq resonance is used.



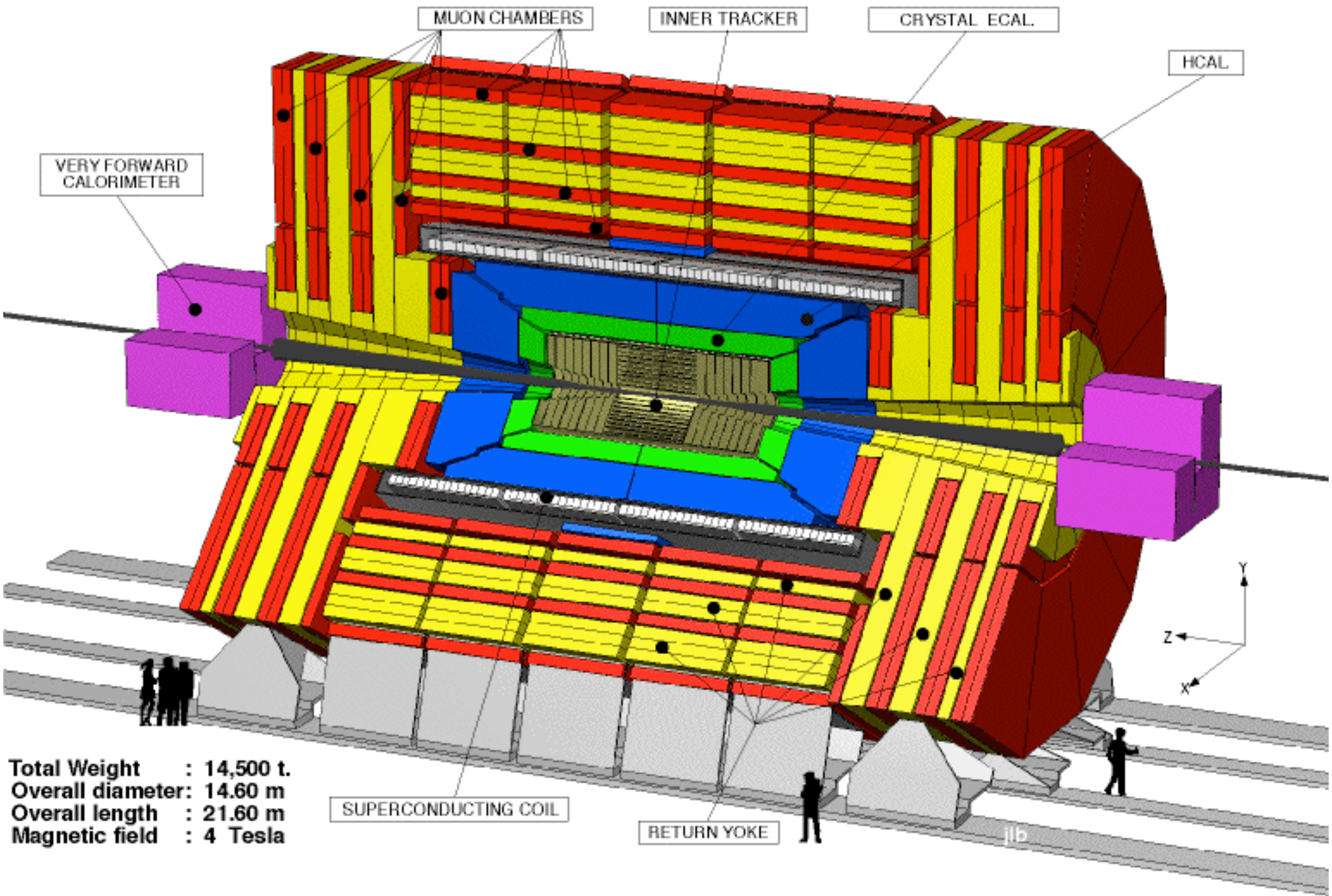
95% C.L. Excluded Mass (TeV)		
	CMS (10 TeV & 10 pb^{-1})	CDF (1.96 TeV & 1 fb^{-1})
Excited quark	M<1.8	M<0.87
Axigluon, Coloron	M<1.8	M<1.25
E_6 diquark	M<1.1 , 1.3<M<1.7	M<0.63

Conclusion

- We are ready to search for new physics at the TeV scale using dijets.
- We plan to search separately for qq, qg and gg resonances.
- CMS should be sensitive to Excited quarks, Axigluon/ Coloron and E_6 Diquark up to ~2 TeV at 95% C.L. with 10 pb^{-1} for 10 TeV collisions
- LHC will operate at 7 TeV soon. We will be able to search for new physics with data.
- New discoveries are highly possible even in early CMS data.

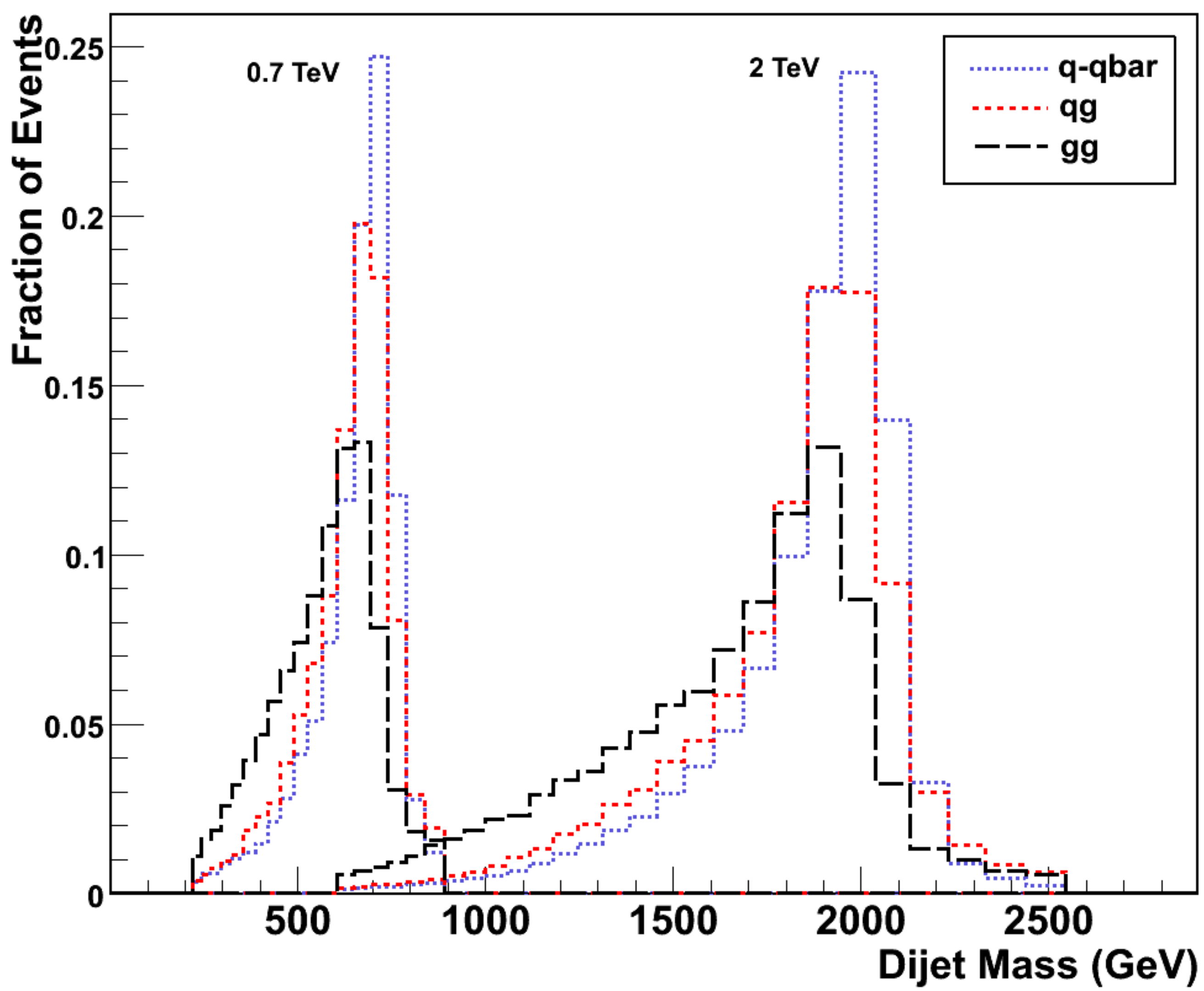
Back-Up Slides

CMS Detector



Resonance Shapes

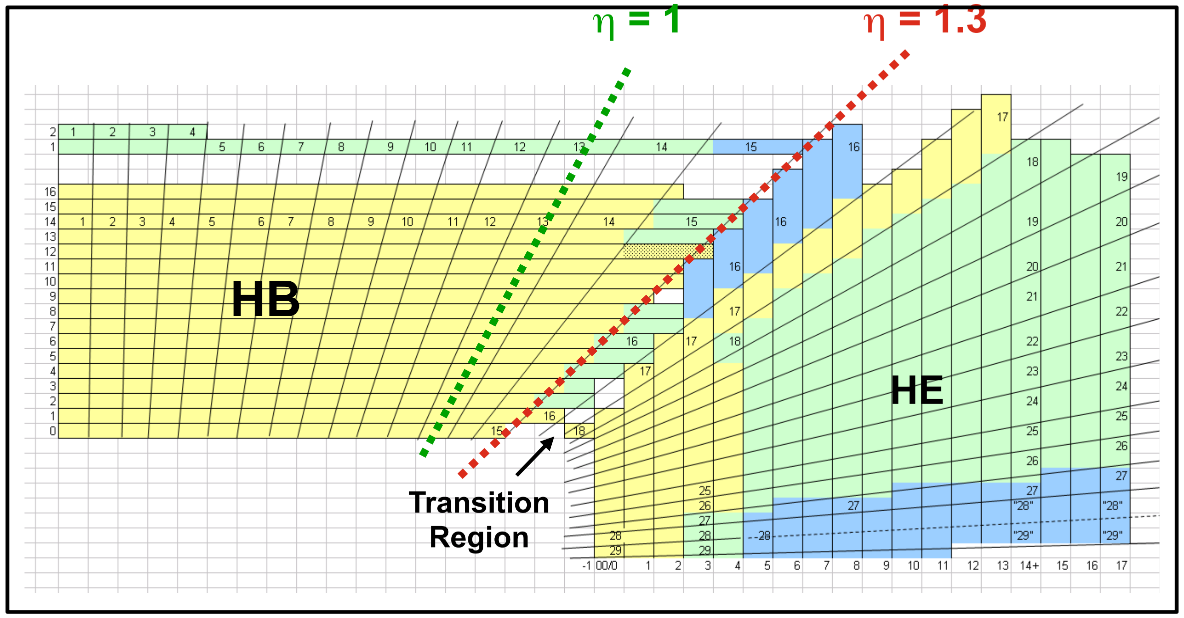
- Dijet resonance shapes from qq, qg and gg have small differences.
    - ✓ Due to differences in ISR, FSR and CMS jet response.

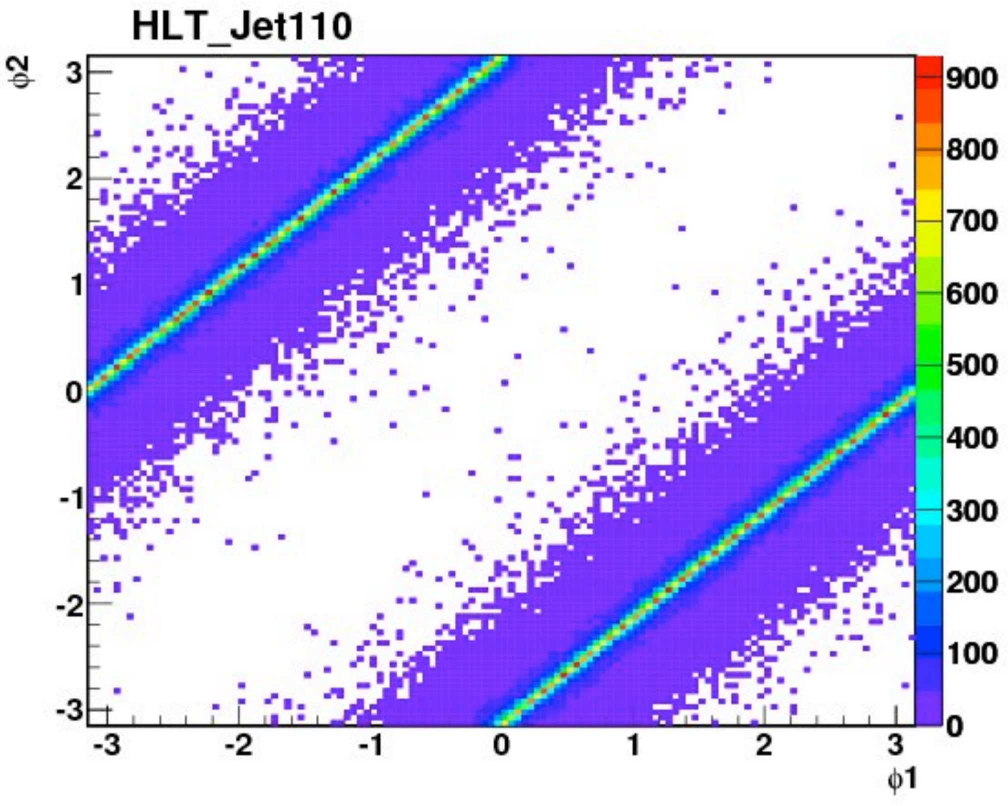


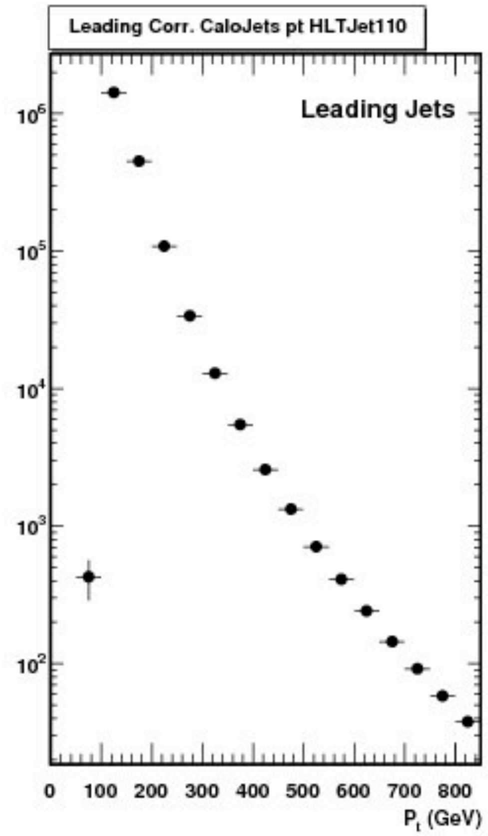
Kinematic Cut

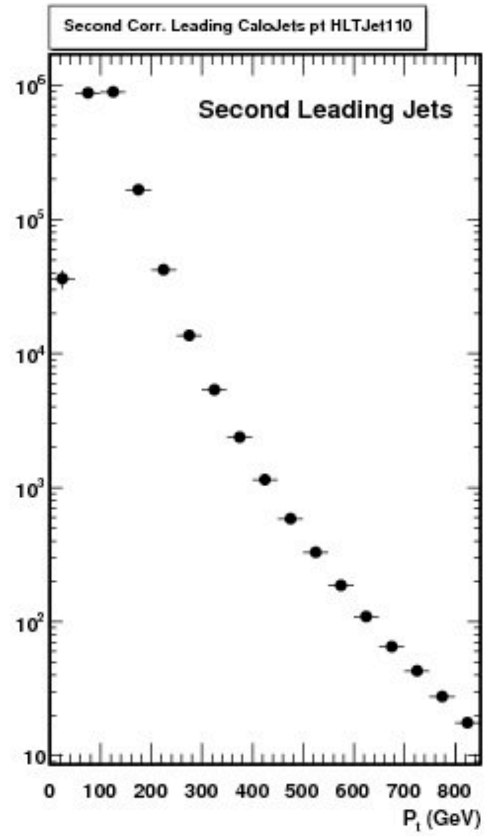
- Two leading jets required to have |η|<1.3
  - ✓ Uniform acceptance
  - ✓ Higher pt reach
  - ✓ Higher sensitivity to new physics

Hcal towers and η cuts



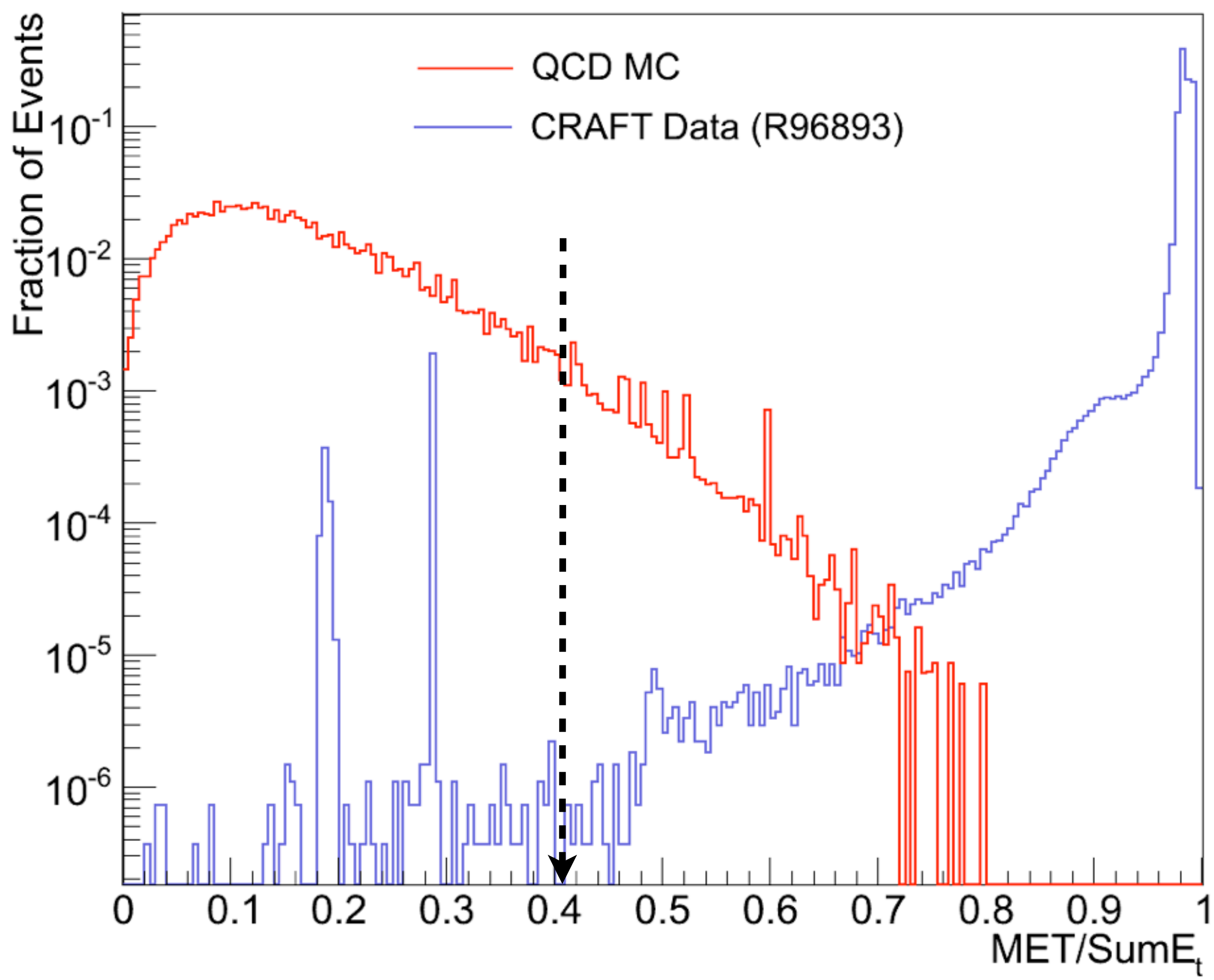






MET/SumEt Cut

- MET/SumEt<0.3 to reject noise, cosmic background, beam halo events.



Effect of Luminosity on Limit

- Shown cross section limit at 10 pb^{-1} and 100 pb^{-1}
- Cross section limit increase about 3 times.
- Consistent with theoretic expectation.

Resonance Model	95% C.L. Excluded Mass (TeV)	
	10 pb^{-1}	100 pb^{-1}
Excited quark	1.9	2.9
Axigluon	1.8	2.8
E_6 diquark	1.0	3.3
W’	N/A	0.9
Z’	N/A	N/A
RS graviton	N/A	0.9

STATISTICAL UNCERTAINTIES ONLY